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# The Efficiency of Maintaining High-Performance Excavators in the Excavation and Loading Processes of Rocks in Angren Coal Deposits


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**ANNOTATION**

*The article mentions the possibilities of using excavators with new high productivity in modern quarries and cuttings. It is one of the advantages of open-pit mining that the use of high-performance giant machinery in quarries is confirmed in the article. Minimizing mining operations and costs has always been a challenge for mining companies. Therefore, keeping high productivity techniques in modern quarries can be one of the solutions to such problems.*


In the Past, Coal was used in industry only as fuel in LESS (thermal power stations) or as raw material for coking coal in metallurgy. By the 21st century due to the rapid development of technology and technology, most of the properties of coal were identified and began to be widely used in practice. This situation led to an increase in demand for coal. Due to the fact that the price of coal on the world market in relation to rare and valuable elements is very low, it was possible to have many problems with its extraction. Delivery of products at competitive prices to the world in particular has been one of the most important issues. One of the most basic conditions for supplying coal to the world at a lower cost is to reduce the cost of coal. To reduce the cost of products, it is necessary to develop a technological complex of effective mining in coal deposits in accordance with the conditions of the mine. Sometimes it is possible to achieve a reduction in the cost of products by adding high-productivity techniques to the component of the coal mining complex, depending on the size, stock, annual productivity and service life of the coal deposits. Even in the article, it was in Angren deposit that mining and loading work was calculated on the rocks using high-performance excavators.

The following factors affect the choice of the technological complex of extraction of mining rocks in open-pit mining operations:

- natural factors (physical and mechanical properties of mined rocks, geological and hydrogeological conditions of the mine, climatic conditions of the area, topography of the quarry area, type and use of minerals, price and reserves);
- technical and technological factors (mining calendar plan, annual productivity by type of mineral and covering mine, parameters and service life of the quarry, transportation distance, dimensions and configuration of the quarry area, requirements for technical operation and environmental protection, product quality of consumers requirements);
- organizational factors (availability of energy and labor resources, equipment selection, equipment delivery and installation period, quarry construction period, transport and other systems);
- Economic factors (possibility of obtaining loans and terms of their payment, permitted capital expenditures), etc.

Taking the productivity of Angren cutting as 18,650,000 $m^3$/year, calculate the annual productivity and number of working fleets of high-performance ECG-15 and ECG-20 excavators in the excavation and loading process below:

Determining the performance of the ECG-15 excavator:

The technical efficiency of mechanical excavators in digging and loading mining rocks in quarries and open pits is calculated as follows.

$$Q_{tech} = \frac{3600 \cdot E \cdot K_e \cdot K_{c.k}}{t_{ds}}, m^3/hour$$

$$K_e = \frac{K_{f.k}}{K_{c.c}},$$

here: $K_{f.k}$ – is the bucket filling coefficient (0.8 ÷ 1), $K_{f.k} = 0.9$ when the excavator digs rock; $K_{c.c}$ – coefficient of crushing of mining rock (1.3 ÷ 1.45) – 1.4

$$K_e = \frac{K_{f.k}}{K_{c.c}} = \frac{0,9}{1,4} = 0,65$$

$K_{s.c}$ – the coefficient of the space (wall) is determined as follows:

$$K_{s.c} = \frac{t_{w.t}}{t_{w.t} + t_{m.t}} = \frac{12}{12+2} = 0,85$$

here: $t_{w.t}$ — we assume that the non-stop working time of the excavator is 12 hours; $t_{m.t}$ — the time of moving the excavator is 2 hours.

$$Q_{tech} = \frac{3600 \cdot 15 \cdot 0,65 \cdot 0,85}{38,16} = 781,8\ m^3/hour.$$

Based on the hourly technical productivity of the excavator in coal cutting, we calculate the operational productivity that it can dig during the shift.

$$Q_{ex}^{op} = Q_{tech} \cdot T_{w.t} \cdot K_{t.u.c}, \quad m^3/shift.$$

here: $T_{w.t}$ – working time of the excavator in one shift is 12 hours; $K_{t.u.c}$ – is the time-use coefficient of the excavator during the shift, which is affected by the type of transport used during the mining of coal cuttings, how the work is organized, and other indicators.

When we choose the car transport for the transportation of mining rocks in coal cutting, its value changes in the range of 0.65÷0.75, therefore, we accept the coefficient of use of the excavator as 0.7.

Based on the obtained data, we determine the operating efficiency of the ECG-15 excavator in one shift.

$$Q_{ex}^{op} = 781{,}8 \cdot 12 \cdot 0{,}7 = 6567\ m^3/shift.$$

We calculate the annual productivity of the ECG — 15 excavator.

$$Q_{ex}^{a.p} = Q_{ex}^{op} \cdot n_{n.w.s} \cdot N_{n.w.d}^{y}, m^3/year.$$

here: $n_{n.w.s}$ – the number of working shifts of the excavator in one day - 2; $N_{n.w.d}^{y}$ – the number of working days of an excavator in a year - 355 days;

$$N_{n.w.d}^{y} = N - (t_{n.h} - t_{n.d.o}), kun$$

here: $N$ – the total number of days in a year - 365 days; $t_{n.h}$ – the number of holidays in one year - 10 days; $t_{n.d.o}$ – the number of days off of the excavator – 0 days.

$$N_{n.w.d}^{y} = N - (t_{n.h} - t_{n.d.o}) = 365 - (10 - 0) = 355\ kun.$$

$$Q_{ex}^{a.p} = Q_{ex}^{op} \cdot n_{n.w.s} \cdot N_{n.w.d}^{y} = 6567 \cdot 2 \cdot 355 = 4662510\ m^3$$

We determine the number of excavators used in the mine:

$$N_{eks} = \frac{Q_{m.e}^{y}}{Q_{ex}^{a.p}}$$

here: $Q_{m.e}^{y}$ – Is the annual productivity of mine mass extraction 18650000 $m^3$/year;

$$N_{ex} = \frac{18650000}{4662510{,}4} = 4\ piece$$

So, it will be enough for us to get 4 ECG-15 excavators to dig and load the mine mass with annual productivity equal to 18650000 $m^3$/year.

From these excavators, we calculate how many excavators we will accept for mining and loading mineral and cover rock:

$$N_{ex}^{m} = \frac{Q_{m}^{y}}{Q_{ex}^{a.p}} = \frac{3252050}{4662510} = 0{,}7\ \approx 1\ ta$$

We accept 1 ECG-15 excavator for mining.

We determine the number of excavators for the cover rock:

$$N_{ex}^{c} = \frac{Q_{c}^{y}}{Q_{ex}^{a.p}} = \frac{15397968}{4662510} = 3{,}3 \approx 3\ ta$$

So, 3 ECG-15 excavators will be needed to ensure the annual productivity of the overburden rock.

**Determining the performance of the ECG-20 excavator:**

The hourly technical productivity of the ECG-20 excavator when digging and loading mining rocks in quarries and cuttings is calculated as follows.

$$Q_{tech} = \frac{3600 \cdot 20 \cdot 0{,}65 \cdot 0{,}85}{32{,}3} = 1231{,}58\ m^3/hour$$

$K_e$ – the coefficient of excavation is determined as follows:

$$K_{e} = \frac{K_{f.k}}{K_{c.c}} = \frac{0,9}{1,4} = 0,65$$

$K_{s.c}$ – is the coefficient of space, taking into account additional work, it is determined as follows:

$$K_{s.c} = \frac{12}{12+2} = 0,85$$

Based on the received data, we determine the operating efficiency of the ECG-20 excavator in one shift.

$$Q_{ex}^{op} = 1231,58 \cdot 12 \cdot 0,7 = 10345,26\ m^3/shift.$$

We calculate the annual productivity of the EKG — 20 excavator.

$$Q_{ex}^{a.p} = Q_{ex}^{op} \cdot n_{n.w.s} \cdot N_{n.w.d}^{y} = 10345,26 \cdot 2 \cdot 355 = 7345134,6\ m^3/year.$$

According to the calculation results, if the annual productivity of the ECG-20 excavator is 7345134.6 $m^3$/year, the total number of excavators is determined as follows:

$$N_{ex} = \frac{18650000}{7345134,6} = 2,54 \approx 3\ pieces.$$

So, it will be enough for us to get 3 ECG-20 excavators to dig and load the mine mass with the annual productivity of coal cutting equal to 18650000 $m^3$/year.

From these excavators, we calculate how many excavators we will accept for mining and loading mineral and cover rock:

$$N_{ex}^{m} = \frac{Q_{m}^{y}}{Q_{ex}^{a.p}} = \frac{3252050}{7345134,6} = 0,5 \approx 1\ piece.$$

We accept 1 ECG-20 excavator for mining.

We determine the number of excavators for the cover rock:

$$N_{ex}^{c} = \frac{Q_{c}^{y}}{Q_{ex}^{a.p}} = \frac{15397950}{7345134,6} = 2,1 \approx 2\ pieces$$

Therefore, 2 ECG-20 excavators are needed to ensure the annual productivity of the overburden rock.

In short, 4 ECG-15 excavators are needed for mining and loading of mining rocks in the Angren section. Of these, 1 ECG-15 excavator will be needed for mineral extraction, and 3 for overburden mining. 3 ECG-20 excavators are needed for digging and loading in the Angren section. Of this, 1 ECG-20 excavator will be needed for mining and loading of minerals, and 2 for mining and loading of overburden.

**Table 1 Comparison of indicators of ECG-15 and ECG-20 excavators**

| No | Indicator name | | ECG-15 | ECG-20 |
|---|---|---|---|---|
| 1 | Required number of excavators | For mineral | 1 | 1 |
| | | For cover rock | 3 | 2 |
| | | Total | 4 | 3 |
| 2 | The maximum starting (flowing) radius, m | | 20 | 21,6 |
| 3 | Maximum digging radius, m | | 22,6 | 24 |
| 4 | Maximum digging height, m | | 16,4 | 18 |
| 5 | Maximum starting (pouring) height, m | | 10 | 11,6 |

Keeping high-performance excavators in mining and loading operations also affects the technological parameters of the quarry. In particular, the width of the working area, the angle of inclination of the bed, the width of the working area, etc. When high-performance ECG-15 or ECG-20 excavators are used in the Angren section, we can see that the number of pogons is significantly reduced due to the increase in the height of the pogon. This, in turn, allows for an increase in the slope of the board, the extraction of less covering rocks, and the transportation of less mine mass. However, due to the reduction of the width of the working area in the lower horizons of quarries and cuttings, problems may arise in the operation of such excavators, and in order to prevent this, additional measures should be taken.

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